



Efficacy of copper oxide wire particles against gastrointestinal nematodes in sheep and goats

F. Soli^a, T.H. Terrill^{a,*}, S.A. Shaik^a, W.R. Getz^a, J.E. Miller^b, M. Vanguru^a, J.M. Burke^c

^a Fort Valley State University, Fort Valley, GA 31030, United States

^b Louisiana State University, Baton Rouge, LA 70803, United States

^c USDA, ARS, DBSFR, Booneville, AR 72927, United States

ARTICLE INFO

Article history:

Received 27 May 2009

Received in revised form 1 October 2009

Accepted 4 October 2009

Keywords:

Copper oxide wire particles

Gastrointestinal nematodes

Goats

Sheep

ABSTRACT

Profitable sheep and goat production in the USA is severely limited by gastrointestinal nematode (GIN) parasitism, particularly by *Haemonchus contortus*. Copper oxide wire particles (COWP) have anti-parasitic properties in the diet of small ruminants, but efficacy of COWP may differ between sheep and goats. In a study with weaned kids (Kiko × Spanish cross, 6 months old) and lambs (Katahdin or Dorper × Blackface crosses, 5 months old), grazing the same pasture area in Central Georgia, 2 g of COWP in a gel capsule was given to half the animals of each species, while the other half were given no COWP. Fecal and blood samples were taken weekly to determine GIN fecal egg counts (FEC) and blood packed cell volume (PCV). After COWP treatment, animals were grazed for 4 weeks and then slaughtered, with adult GIN recovered from the abomasum and small intestines for counting and identification to species. For both sheep and goats, COWP treatment reduced EPG ($P < 0.05$), increased PCV ($P < 0.05$), and lowered abomasal GIN numbers ($P < 0.05$). For EPG, these differences were 82.5 and 90.5% for sheep and goats, respectively, 26 days after treatment, while adult *H. contortus* were 67.2 and 85.8% lower for COWP-treated sheep and goats, respectively. In this study, COWP treatment was equally effective against *H. contortus* infection in lambs and kids and appears to be an effective method of controlling *H. contortus* infection for up to 6 weeks in small ruminants following weaning.

© 2009 Elsevier B.V. All rights reserved.

1. Introduction

Infection with gastrointestinal nematodes (GIN), primarily *Haemonchus contortus*, a blood-feeder that can cause severe anemia in infected animals, is the primary constraint to profitable sheep and goat production where this parasite is endemic, including the southeastern USA. Broad-spectrum drugs have been the basis of control strategies in the past, but these drugs now have reduced efficacy due to widespread development of anthelmintic resistance in sheep and goat GIN (Terrill et al., 2001; Mortensen et al., 2003; Howell et al., 2008). Alternative

GIN control methods are urgently needed to sustain small ruminant industries in the USA. One of these is treatment with copper oxide wire particles (COWP). These are commercially available in 25 g boluses (Copasure; Animax Veterinary Technology, UK) that can be repacked into 2 g gel capsules for sheep and goats. The capsule is administered into the animals' abomasum by inserting at the back of the throat using a pill gun.

A number of experiments with sheep has shown high efficacy of COWP against *H. contortus*, particularly in young animals (Burke et al., 2004; Burke and Miller, 2006; Burke et al., 2007a). Results from a small number of COWP trials with GIN-infected goats have been reported, but often with apparent lower efficacy results than with sheep trials (Burke et al., 2007b). These trials have been conducted in locations with differing GIN populations. To date, no direct

* Corresponding author. Tel.: +1 478 825 6814; fax: +1 478 825 6376.
E-mail address: terrillt@fvsu.edu (T.H. Terrill).

comparison of COWP efficacy has been made between sheep and goats grazing together and subjected to infection by the same GIN population. Therefore, a study was designed to test efficacy of 2 g COWP in gel capsules against GIN in sheep and goats grazing the same pasture area at the Fort Valley State University Agricultural Research Station in Central Georgia in the southern US.

2. Materials and methods

2.1. Animal welfare

All animal procedures used in this study were approved by the Fort Valley State University Institutional Animal Care and Use Committee.

2.2. Experimental design and protocol

A grazing study with young goat bucks (Kiko \times Spanish cross, 6 months old; $n = 12$) and female lambs (Katahdin or Dorper \times Blackface crosses, 5 months old; $n = 12$) was completed at the Fort Valley State University Agricultural Research Station, Fort Valley, Georgia, during August and September, 2007. Prior to starting the trial, the goats acquired a natural GIN infection by grazing perennial summer grass pasture {primarily bermudagrass [*Cynodon dactylon* (L.) Pers]], and bahiagrass (*Paspalum notatum* Flugge)} for approximately 4 months. Fecal samples were collected weekly from individual animals to monitor fecal egg counts (FEC). When FEC were sufficiently high (approximately 3000 and 1500 for lambs and kids, respectively), the lambs and kids were randomly assigned to 1 of 2 treatment groups such that both lamb and kid groups had similar total eggs per gram (EPG). The treatments consisted of: (1) 2 g of COWP in a gel capsule administered per os using a pill gun, and (2) no COWP. After treatment, all the animals were grazed together on the same pastures as described previously, for 28 days, after which half the animals in each treatment group were randomly selected and removed from the grazing area for slaughter. The remaining animals were allowed to continue grazing for an additional 14 days, after which the trial was terminated.

2.3. Sampling procedures and analysis

Throughout the grazing period after COWP was administered, blood and rectal fecal samples were collected from individual animals weekly for PCV and FEC determination, respectively. All FEC determinations were made on fresh feces. Eggs per gram of feces were counted using a modified McMaster procedure (Whitlock, 1948) and PCV was determined using a Marathon 6K micro-hematocrit centrifuge and reader (Fisher Scientific, Pittsburgh, PA).

2.4. Recovery and counting of adult nematodes

Adult GIN from abomasum and small intestines were recovered, counted, and identified to species using the procedures described by Shaik et al. (2006). The abomasal

and small intestinal contents for each animal were washed into plastic buckets, brought up to 3 L with tap water, vigorously mixed, and then subsampled (2 aliquots of 150 mL each). The adult GIN were preserved by adding 100 mL of 10% buffered formalin solution (Sigma–Aldrich, St. Louis, MO) to each container. The GIN were recovered from one of the aliquots and counted using a Leica Zoom 2000 phase contrast microscope (Leica Microsystems Inc., Chicago, IL).

2.5. Statistical analyses

Fecal egg count and PCV data were analyzed as a repeated measures analysis in a completely randomized design using the mixed model procedure of SAS (SAS Institute, 1992), with treatment, species, and species \times treatment interaction in the model. Adult GIN data were analyzed as a completely randomized design using the GLM procedure of SAS. The FEC and adult GIN data were log-transformed prior to statistical analysis to normalize the data. When treatment effects were different at $P < 0.05$, means were separated using LSD test. Fecal egg count and adult GIN data are reported as least squares means of untransformed data, with statistical inferences based upon log-transformed data analysis.

3. Results

3.1. Fecal egg counts

In both sheep and goats, treatment with 2 g of COWP significantly reduced ($P < 0.01$) FEC compared with control animals during the 28-day trial period (Fig. 1). After 12 days, FEC of COWP-treated sheep and goats were 94.3 and 74.9% lower, respectively, than untreated animals, while these differences were 82.5 and 90.5% for sheep and goats 26 days after treatment. Following the removal of half the animals in each treatment group for slaughter and worm recovery, there were significant treatment ($P < 0.01$) and

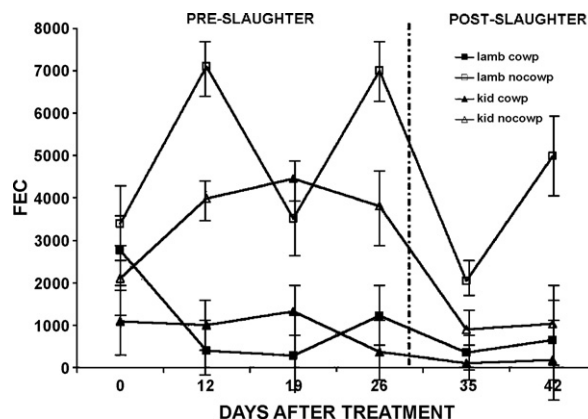


Fig. 1. Effect of copper oxide wire particles (COWP, 2 g bolus) on fecal egg counts (FEC) of naturally infected lambs (COWP-treated, solid squares; no COWP treatment, open squares) and kids (COWP-treated, solid triangles; no COWP treatment, open triangles) grazing summer pasture in Georgia. Least squared means and standard errors are presented, and statistical analysis of FEC was completed on log-transformed values.

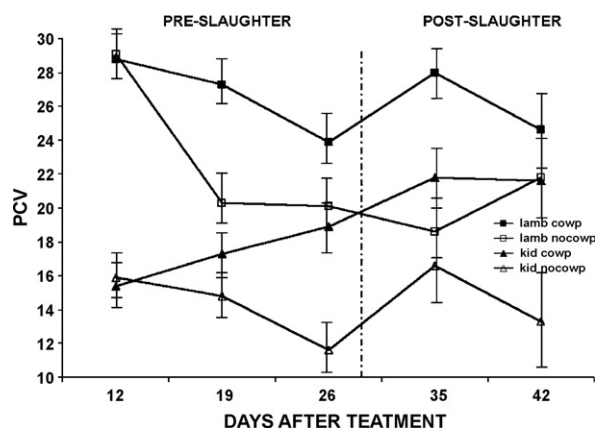


Fig. 2. Effect of copper oxide wire particles (COWP, 2 g bolus) on blood packed cell volume (PCV) of naturally infected lambs (COWP-treated, solid squares; no COWP treatment, open squares) and kids (COWP-treated, solid triangles; no COWP treatment, open triangles) grazing summer pasture in Georgia. Least squared means and standard errors are presented.

species ($P < 0.05$) differences in FEC in the remaining animals between 28 and 42 days after COWP administration. The FEC of COWP-treated sheep and goats were 87.2 and 83.5% lower than non-treated animals, respectively, by day 42 of the experiment. Throughout the whole trial, the average FEC was higher in sheep than in goats.

3.2. Blood packed cell volume

There were significant treatment ($P < 0.01$) and species ($P < 0.01$) effects on blood PCV values (Fig. 2). The animals treated with COWP had higher ($P < 0.05$) PCV values than controls from days 21 to 42 of the experiment. Sheep had higher ($P < 0.01$) PCV than goats throughout the study.

3.3. Adult nematodes

Treatment with COWP reduced total *H. contortus* counts in the abomasum of both sheep ($P < 0.05$) and goats

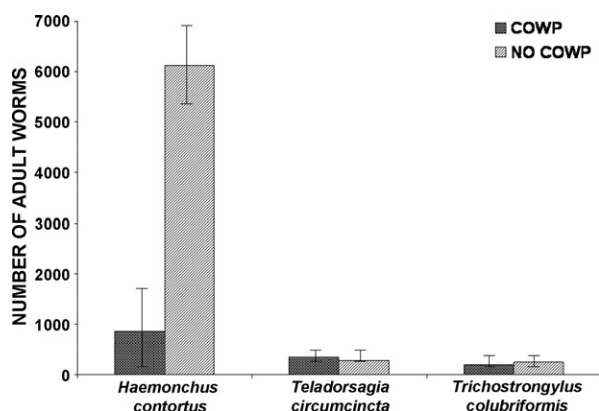


Fig. 3. Effect of copper oxide wire particles (COWP, 2 g bolus) on adult gastrointestinal nematodes (worms) of naturally infected goats grazing summer pasture in Georgia.

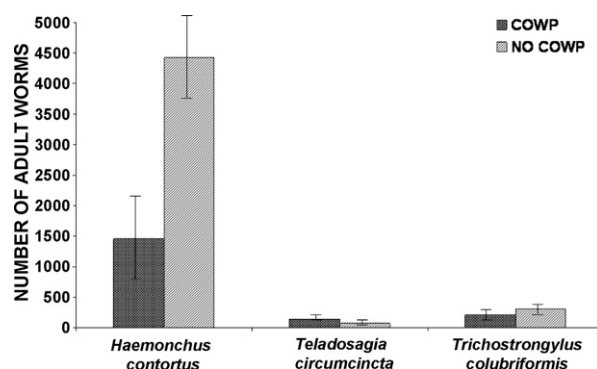


Fig. 4. Effect of copper oxide wire particles (COWP, 2 g bolus) on adult gastrointestinal nematodes (worms) of naturally infected sheep grazing summer pasture in Georgia.

($P < 0.01$), but had no effect on *Teladorsagia circumcincta* (abomasum) or the small intestinal worm *Trichostrongylus colubriformis* (Figs. 3 and 4). The reduction in number of adult *H. contortus* due to COWP treatment was 67.2 and 85.8% for sheep and goats, respectively. Because the overall worm burden in each species was over 90% *H. contortus*, there was also a significant reduction in total GIN in both sheep and goats ($P < 0.01$) due to COWP treatment. These differences were 62.7 and 78.7%, respectively.

4. Discussion

Treatment with 2 g of COWP in a gel capsule effectively reduced GIN burden in both lambs and kids in the current study. Similar results have been observed with young animals in the literature (Bang et al., 1990; Burke et al., 2004, 2005b, 2007a; Burke and Miller, 2006). Burke et al. (2004) reported that 2, 4, and 6 g doses of COWP were all highly effective against a predominantly *H. contortus* infection in 5–6 months old hair breed lambs. In a follow-up study with lambs, Miller et al. (2005) found similar effectiveness using lower COWP doses of 0.5, 1.0, and 1.5 g. Treatment with COWP up to a 4 g dose may be less effective in mature sheep than in lambs (Burke et al., 2005a, 2007a), although there was no direct comparison made. Previous studies on COWP effectiveness against GIN infection in goats have been variable as well, with better results reported for weaned kids than for more mature animals, although there were fewer *H. contortus* in the mature goats (Burke et al., 2007b). Doses of COWP from 0.5 to 4 g all reduced FEC of weaned Boer × Spanish cross kids by 75–85%, while COWP doses up to 10 g were less effective or not effective against GIN of more mature goats that had more intestinal than abomasal worms (Burke et al., 2007b).

In previous reports, there were no direct comparisons of COWP effectiveness in sheep and goats grazing the same pasture and exposed to the same GIN population. There were species differences in initial FEC and anemia scores in the current study, with higher FEC and PCV values in the lambs compared with the kids. Sheep can generally tolerate a higher infection rate than goats and still be productive (J.E. Miller, pers. comm.). Despite these

differences in infection rate between lambs and kids, COWP appeared to be equally effective as an anti-parasitic agent in both species in the current study. The initial reduction in FEC was more pronounced in the lambs, but on a percentage basis, there was not much difference between the two species. In both species, the reduction in FEC in COWP-treated animals compared to untreated controls ranged from 75 to 95% throughout the trial, and this reduction was maintained for 42 days after treatment. Blood PCV was markedly improved by COWP treatment in both the lambs and kids, although there was a slight decline over the course of the trial in lambs, whereas PCV increased by approximately four percentage points in the kids (Fig. 2).

The reduction in adult *H. contortus* numbers in the abomasum of 67.2% for lambs is less than previously reported for lambs given 2–6 g COWP boluses in a study by Burke et al. (2004), in which the lambs were slaughtered 26 days post-treatment. The longer post-treatment period prior to slaughter in the current study (42 days) may have allowed some reinfection to occur, which might account for these differences. Previous reports on goats given 0–10 g of COWP did not include adult nematode data, but 85.8% reduction in *H. contortus* indicates very good efficacy against this parasite at the 2 g COWP dose level in goats in the current investigation. Generally high efficacy of COWP for both sheep and goats in this study is most likely related to the overall GIN infection in each species being >90% *H. contortus*. Because COWP are less effective against *T. circumcincta* or *T. colubriformis* than *H. contortus* (Bang et al., 1990; Knox, 2002), the season of the year when the trial is completed makes a difference in the results, as *T. circumcincta* and *T. colubriformis* are more prevalent in the cooler months of the year. The current investigation was completed in the summer when the predominant infection was *H. contortus*.

5. Conclusions

Copper oxide wire particles effectively reduced *H. contortus* populations in kids and lambs grazing the same pasture and sharing a genetically similar worm population. Treatment with COWP at the 2 g level appears to be a viable option for controlling GIN infection in weanlings for both species when a predominant *H. contortus* infection is present. Further investigation with mature sheep and goats grazing the same pasture would be needed to

compare the difference in the efficacy of COWP between adults of the two species.

Acknowledgements

The authors would like to thank the USDA 1890 Institution Teaching and Research Capacity Building Grants Program (Award No. 2005-38814-16429) and USDA CSREES IOP (Project No. 2005-51300-02392) for funding support of this work.

References

- Bang, K.S., Familton, A.S., Sykes, A.R., 1990. Effect of copper oxide wire particle treatment on establishment of major gastrointestinal nematodes in lambs. *Res. Vet. Sci.* 49, 132–137.
- Burke, J.M., Miller, J.E., Olcott, D.D., Olcott, B.M., Terrill, T.H., 2004. Effect of copper oxide wire particles dosage and feed supplement level on *Haemonchus contortus* infection in lambs. *Vet. Parasitol.* 123, 235–243.
- Burke, J.M., Miller, J.E., Brauer, D.K., 2005. The effectiveness of copper oxide wire particles as an anthelmintic in pregnant ewes and safety to offspring. *Vet. Parasitol.* 131, 291–297.
- Burke, J.M., Miller, J.E., Larsen, M., Terrill, T.H., 2005. Interaction between copper oxide wire particles and *Duddingtonia flagrans* in lambs. *Vet. Parasitol.* 134, 141–146.
- Burke, J.M., Miller, J.E., 2006. Evaluation of multiple low doses of copper oxide wire particles compared with levamisole for control of *Haemonchus contortus* in lambs. *Vet. Parasitol.* 139, 145–149.
- Burke, J.M., Morrical, D., Miller, J.E., 2007. Control of gastrointestinal nematodes with copper oxide wire particles in a flock of lactating polypay ewes and offspring in Iowa, USA. *Vet. Parasitol.* 146, 372–375.
- Burke, J.M., Terrill, T.H., Kallu, R.R., Miller, J.E., Mosjidis, J., 2007. Use of copper oxide wire particles to control gastrointestinal nematodes in goats. *J. Anim. Sci.* 85, 2753–2761.
- Howell, S.B., Burke, J.M., Miller, J.E., Terrill, T.H., Valencia, E., Williams, M.J., Williamson, L.H., Zajac, A.M., Kaplan, R.M., 2008. Anthelmintic resistance on sheep and goat farms in the southeastern United States. *JAVMA* 233, 1913–1919.
- Knox, M.R., 2002. Effectiveness of copper oxide wire particles for *Haemonchus contortus* control in sheep. *Aust. Vet. J.* 80, 224–227.
- Miller, J.E., Burke, J.M., Terrill, T.H., 2005. Effect of 0.5, 1.0 and 1.5 gram copper oxide wire particles on natural infection in lambs. *J. Anim. Sci.* 83 (Suppl. 2), 15 (abstract).
- Mortensen, L.L., Williamson, L.H., Terrill, T.H., Kircher, R.A., Larsen, M., Kaplan, R.M., 2003. Evaluation of prevalence and clinical implications of anthelmintic resistance in gastrointestinal nematodes in goats. *JAVMA* 223, 495–500.
- SAS Institute, 1992. SAS/STAT Software: changes and enhancements. Release 6.07. SAS Technical Report, SAS Institute, Cary, NC.
- Shaik, S.A., Terrill, T.H., Miller, J.E., Kouakou, B., Kannan, G., Kaplan, R.M., Burke, J.M., Mosjidis, J., 2006. Sericea lespedeza hay as a natural deworming agent against *Haemonchus contortus* infection in goats. *Vet. Parasitol.* 139, 150–157.
- Terrill, T.H., Kaplan, R.M., Larsen, M., Samples, O.M., Miller, J.E., Gelaye, S., 2001. Anthelmintic resistance on goat farms in Georgia: efficacy of anthelmintics against gastrointestinal nematodes in two selected goat herds. *Vet. Parasitol.* 97, 261–268.
- Whitlock, H.V., 1948. Some modifications of the McMaster helminth egg-counting technique apparatus. *J. Coun. Sci. Ind. Res.* 21, 177–180.